Phase I Project Summary

Firm: Intelligent Automation, Inc.
Contract Number: NNX11CE03P
Project Title: Security-Enhanced Autonomous Network Management for Space Networking

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

The key innovation of this effort is the development of a Metroplex-based arrival, departure, and surface optimization system which we call MetroSim. Linking with both the NASA-developed Traffic Management Advisor (TMA) tool, the NASA-developed System Oriented Runway Management (SORM) tool, the FAA-proposed Terminal Flight Data Management (TFDM) system, or alternatively with live or recorded flight data, MetroSim allows airport planners, traffic flow management experts, airline dispatchers, air traffic controllers, and pilots to reduce the uncertainty in operations planning, recover quickly from disruptive events, maintain high throughput even in adverse weather conditions, and handle the uncertainties associated with irregular operations. The importance of MetroSim is significant. Up to this point, air traffic management systems consider arrivals and departures as separate streams to be handled in a disjoint manner. The main reason is that arrivals are generally fixed by the enroute system, while departures are subject to high uncertainties involving surface traffic movement (taxi times, queue times, and even gate pushback times).

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

The overall objective of the project is to develop a prototype version of Metrosim so that its feasibility can be assessed. During Phase I, we will design the basic Metrosim product and test whether or not the result is feasible by using recorded data from the New York Metroplex (N90). The design will follow a distributed architecture to allow fast execution and quick reconfiguration of the tools if necessary, relying on "thin interfaces" between the modules to enhance maintainability and for fast run-time execution. The primary objective of Phase 1 is to fully specify the components of Metrosim—the Metroplex Planner and the Airport Planner—and demonstrate its feasibility. Thus the objectives of Phase 1 are threefold: (1) develop a prototype of MetroSim, in a combination of the "Matlab" programming language and the Java programming language; (2) demonstrate that the prototype works for a sample day, by comparing what MetroSim would decide from a given day's flight sample to what actually occurred on that day, and (3) as a result of the experience, further refine MetroSim as a set of requirements to be outlined in a Phase II proposal.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

In our Phase I efforts, we implemented the two components of Metrosim, the Metroplex Planner (in Java) and the Airport Planner (as a mixed integer-linear program (MILP)). The Metroplex Planner is responsible for route selection for both arrivals and departures from a Metroplex. The Airport Planner is responsible for runway assignments, wheels on/off times, and surface taxi operations. The Airport Planner accomplishes these goals by using two submodules. The first submodule is the Combined Arrival-Departure Scheduler (CADS), which optimizes the runway throughput by assigning flights to runways and computing wheels on-off times using a MILP formulation. The second submodule optimizes surface operations, including taxi paths and minimizes departure queue holding time, also with an MILP formulation. These components were then tested using recorded data for a busy day at the New York Metroplex (N90), where two airports were configured in Metrosim. The result showed that Metrosim can process the MILP equations in a few minutes, that the Metroplex Planner can also run in a few minutes, and that the final result shows, for the test, an increase in throughput of about 15% compared to the recorded data.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

Metrosim can be used as a research tool for NASA aviation researchers. By experimenting with different algorithms for the Metroplex Planner or the Airport Planner, or even by providing Metrosim with a different route structure or different traffix mix, a NASA researcher can explore many areas. Some of these areas are (1) the effect of a different route structure on the Metroplex performance; (2) the introduction of new vehicle types, such as UAS aircraft, on Metroplex performance; (3) the effect of a different traffic mix or traffic intensity on Metrosim metrics.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

The proposed solution has application in every Metroplex in the National Airspace System. The way Metrosim is designed, it can be adapted to any Metroplex. Metrosim can be a decision support tool for controllers, advising them on the best routes, best departure and arrival sequence for each airport, and best pushback time and taxi route to the assigned runway. It can be used inside a human-in-the-loop simulation, as a "pseudo controller" to provide pilots with guidance. Finally, airline dispatchers can use the tool to aid them in route planning, to clue them on what routes and taxi paths are likely to be assigned by controllers long before a flight departs or (for arrivals) enters the Metroplex

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